LBNE Beam Simulations

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8 November 2013

Introduction

- In this talk
  - Overview of LBNE Beam Simulations Group
  - Overview of G4LBNE
  - Current Beam Simulations Work
  - Future Beam Simulation Plans

Overview of LBNE Beam Sim Group

- The roles of the LBNE beam simulation group
  - Maintain the G4LBNE flux simulation:
    - Provide flux files to other members of the collaboration
    - Keep simulation up to date with beam design changes
    - Add functionality as needed
  - Provide input on beamline optimization:
    - How do changes to e.g. horns, decay pipe, targets change the flux
  - Study beam systematics and tolerances

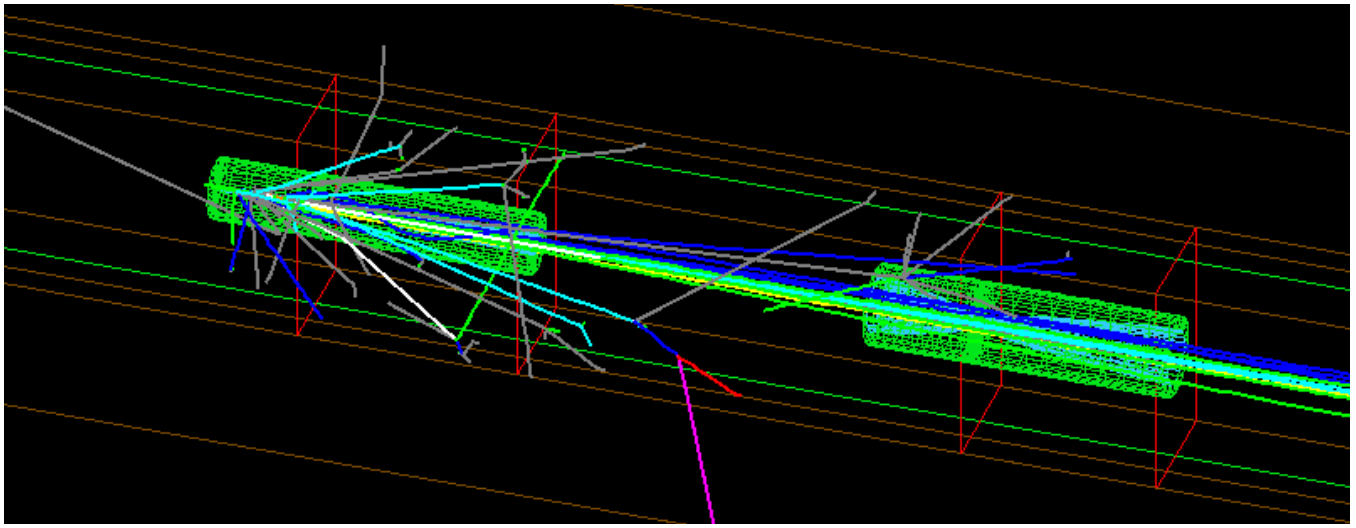
Overview of LBNE Beam Sim Group

- Who we are:
  - Conveners: Laura Fields (Northwestern) and Kevin Yarritu (LANL)
  - Beamline experts: Jim Hylen, Vaia Papadimitriou, Alberto Marchionni, Bob Zwaska (FNAL)
  - Active members: Paul LeBrun (FNAL), Seongtae Park (UTA), John LoSecco (Notre Dame), several UTA, UH students
  - In most cases, people spend small fractions of their time on beam simulations → not much manpower (maybe 1-2 FTE) given all that we are charged with

Overview of G4LBNE

- As of a few months ago, G4LBNE was
  - A fork of G4NUMI; differences included
    - NuMI→LBNE in a bunch of file names (LBNEDetectorConstruction.cc, LBNEDataInput.cc, etc)
    - Different beamline parameters where relevant (decay pipe size, horn current, proton beam size, etc)
    - Many beam parameters can be varied at runtime via an input file

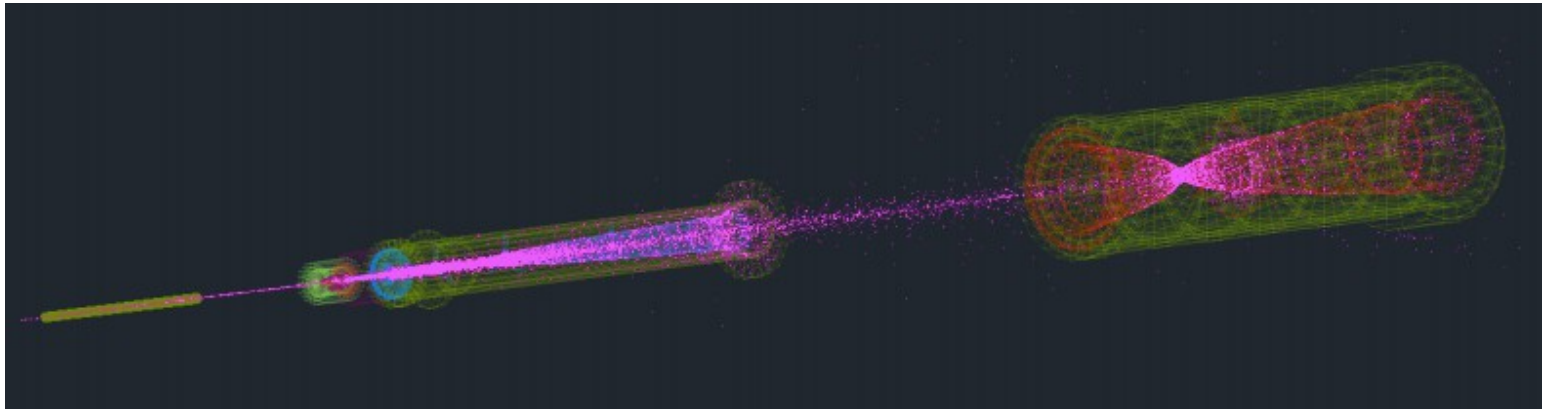
Original author was Laura Loiacono



Overview of G4LBNE

- But there have been significant changes in the last few months
  - Geometry has been completely rewritten and reorganized
    - E.g. LBNEDataInput.cc and input file are completely gone
    - Many changes to the beamline that were not possible before are now possible without overlapping geometries
    - All changes are made via macro commands
    - Much more detailed geometry

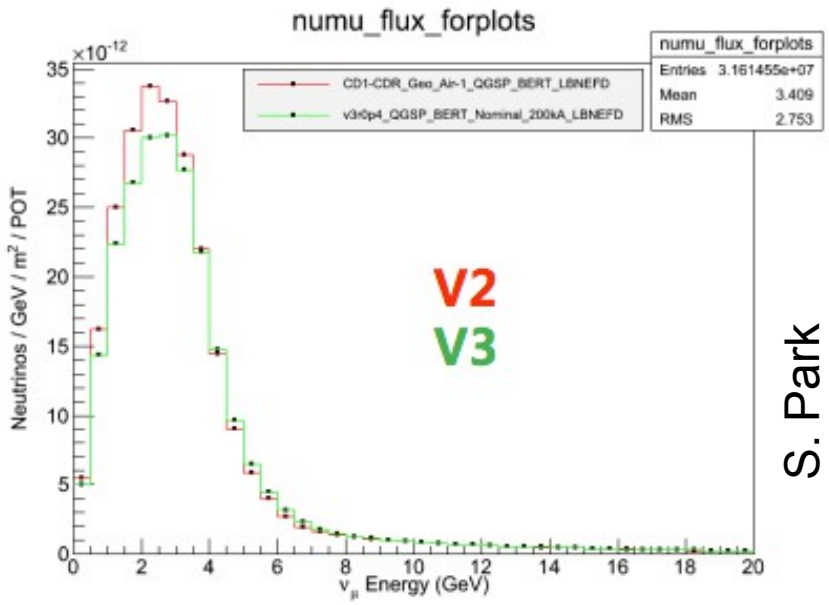
Geometry rewrite was done by Paul LeBrun



Overview of G4LBNE

- Benchmarking the new version
  - Validation of the new geometry is difficult
  - Primarily done through step-by-step visualization of the elements, geantino studies, plots of neutrino parent production vertices
  - Also through studies of beamline changes; e.g. when we shift a horn, does the flux change and we expect?

Peak flux is about 10% lower with new geometry; even the old geometry was significantly lower than MARS simulations

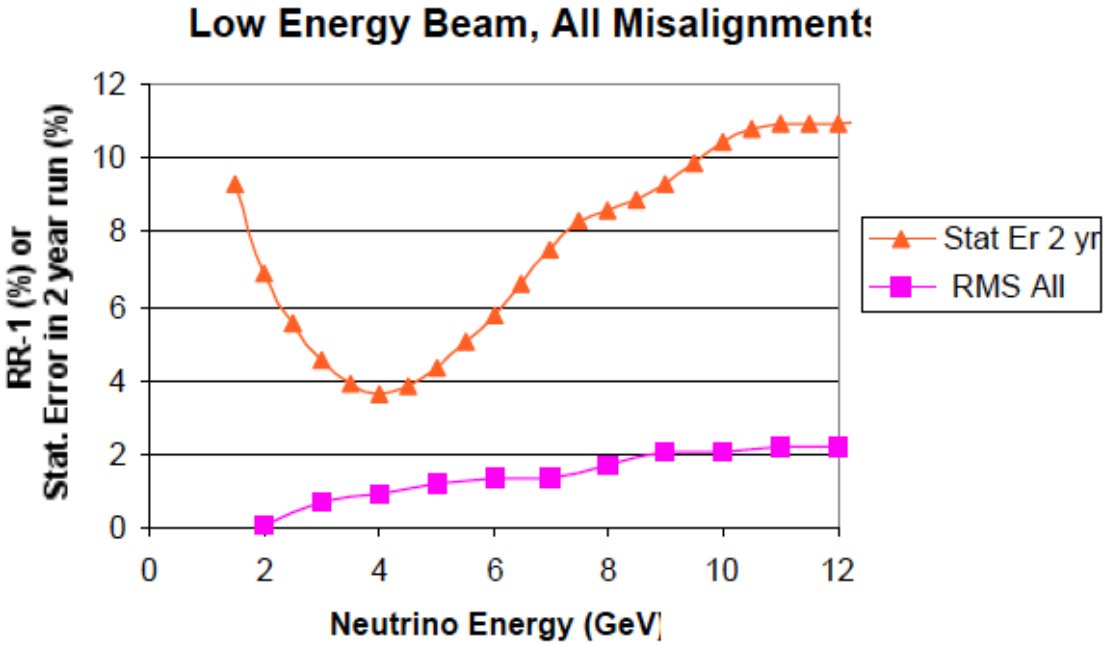


S. Park

We believe the new geometry is an accurate description of the current LBNE beamline design; We can now proceed with using G4LBNE to optimize the design.

Current Activities

- The current focus of the group is on setting alignment tolerances.
  - Must be done in the next few months to provide input on hadron monitor design
  - Difficult because analysis infrastructure to understand the impact of alignment uncertainties on LBNE physics goals is still in development.



Because of time constraints, will initially follow NuMI procedure to establish first set of tolerances

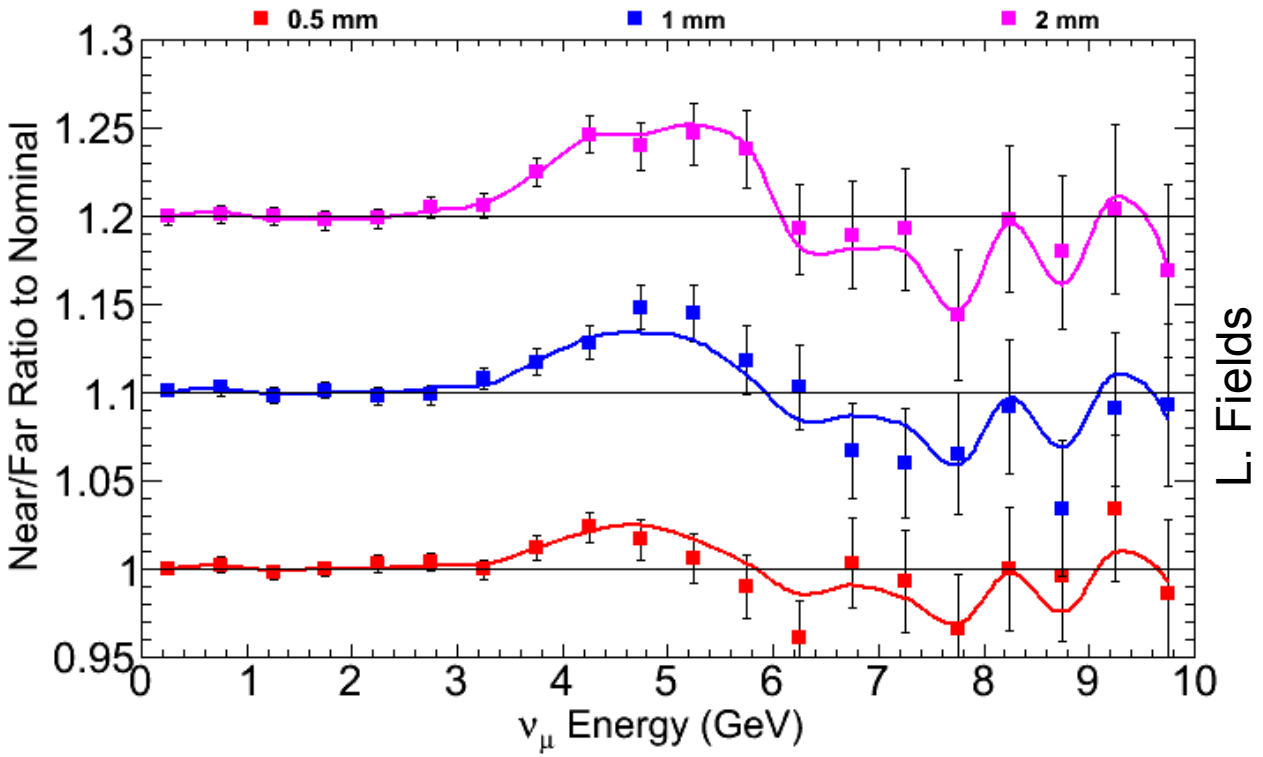
Require tolerances small compared to far detector statistical uncertainties

Will feed the resulting systematic errors into LBNE analysis infrastructure to understand the impact of mass hierarchy and CP violation measurements.

NuMI TDH

Current Activities

- An example alignment tolerance study – Horn 1 Tilt:

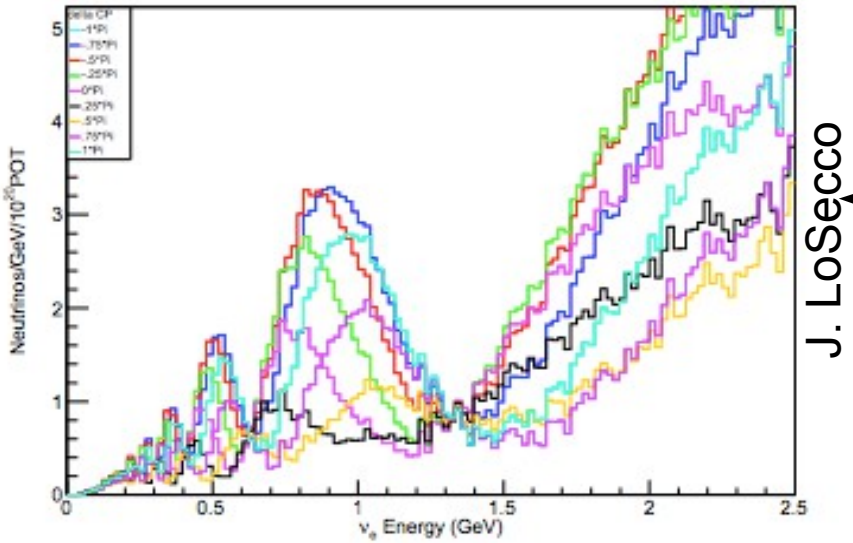


While most alignment variations show the same trends as in NuMI, there are differences.

For example, the LBNE flux appears to be more sensitive to the Horn 1 angle than the NuMI flux was, for reasons that are not yet understood

Current Activities

- John LoSecco is also studying beamline changes that would optimize the low energy flux:



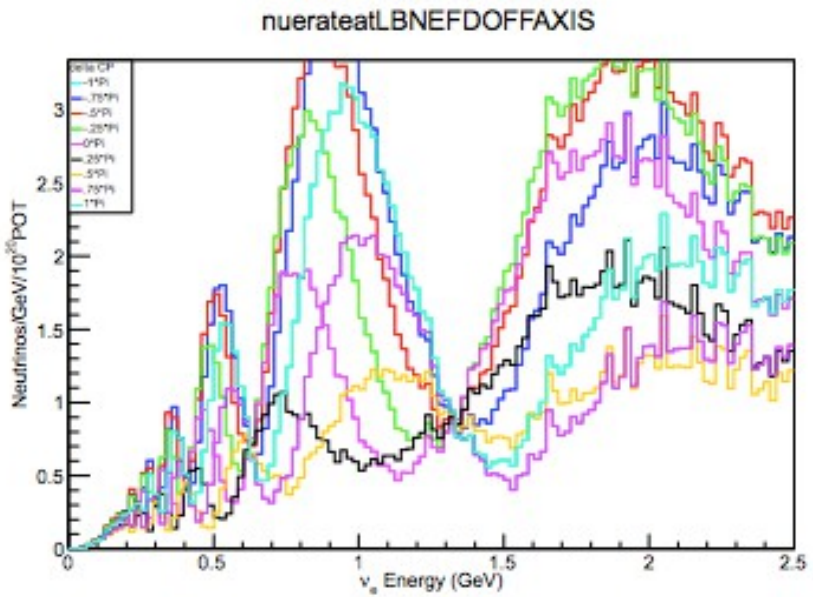
J. LoSecco

Oscillated nu_e flux for several values of delta_CP

On Oxis

Oscillated nu_e flux for several values of delta_CP

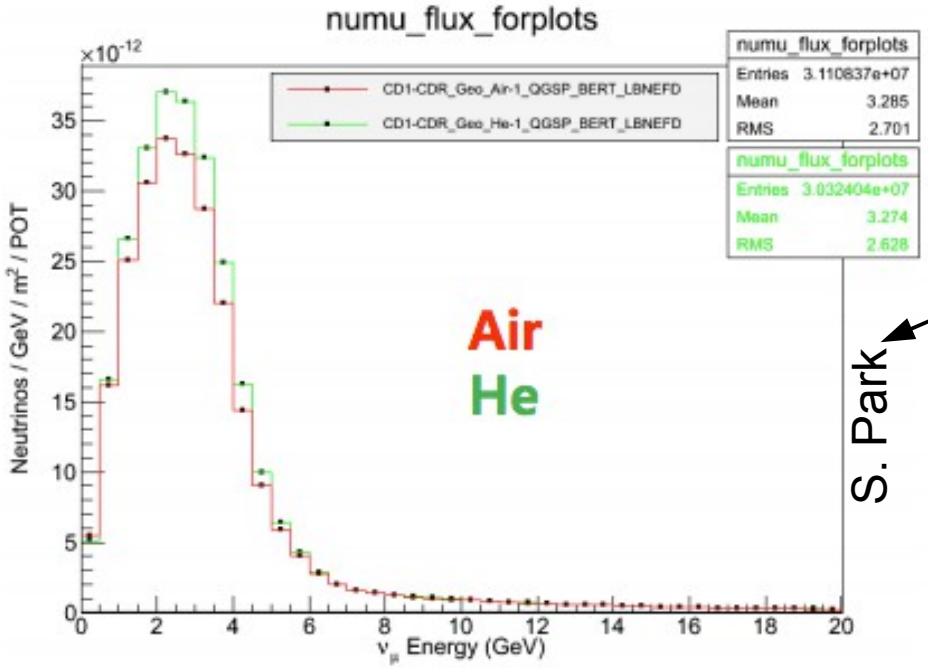
Off Oxis



J. LoSecco

Current Activities

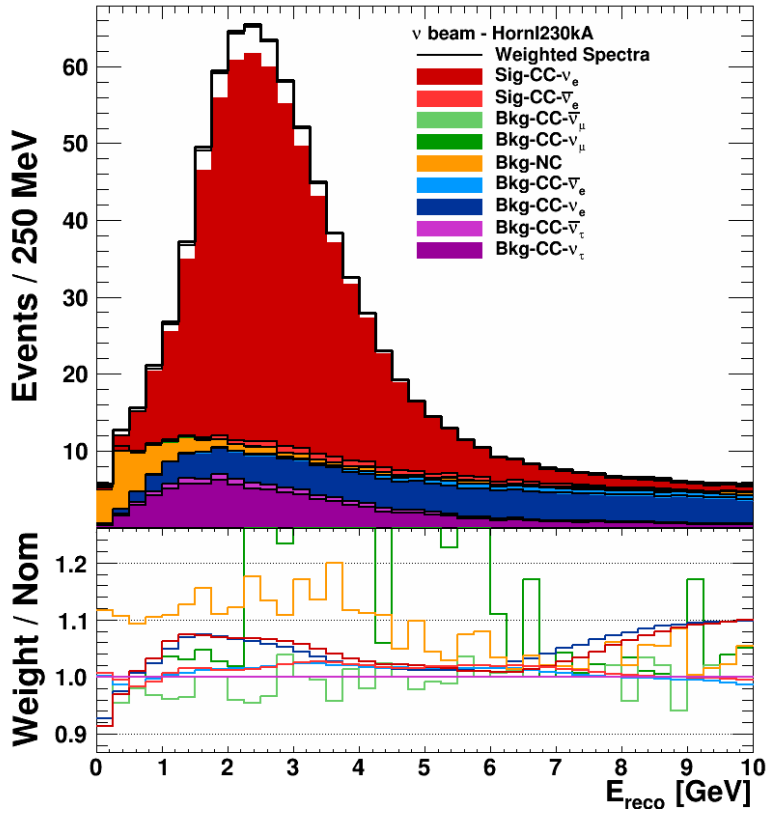
- Other beam design studies studies:



S. Park

Helium vs. Air

200 vs 230 kA



L. Fields/ D. Cherdack

Future Plans

- Some of our near-term plans
  - Add ability to save information about different particles as they move through the beamline, not just neutrinos; needed for
    - Optimization/study of muon monitors
    - Hadron absorber studies
    - Likely many other use cases;
      - e.g. We recently had a NuStorm-related request for distributions of pions after Horn 1
  - Other improvements to G4LBNE output:
    - Full parentage information of neutrinos
    - Neutrino Ntuple in the DK2NU format for use with GENIE Flux Driver

Future Plans

- Some of our near-term plans
  - Many more beam design studies studies
    - Optimization of target width, target length, target position, horn spacing, horn current, target material, target shape
    - Particularly important: develop infrastructure to propagate all of these changes through LBNE's analysis infrastructure
  - Estimate hadron production systematics:
    - We want to implement hadron production reweighting, a la MINERvA
      - Useful for understanding the impact of hadron production systematics with existing data; also for studying how new hadron production data would improve uncertainties;

The End